

## **ATTACHMENT DR 14**

# **SCOUR AND EROSION ANALYSIS**

---

Subject      **Data Request 14: Scour and Erosion Analysis**  
Responses to Data Requests – Set 1  
Blythe Solar Power Project (09-AFC-6C)

---

From          David A. Jaffe, PhD, PE, D.WRE, and Casey Dick, AECOM

---

Date          June 17, 2013

---

**Introduction:**

The purpose of this memorandum is to provide an analysis of the potential scour and erosion that could occur during a 100-year, 24-hour design storm event in the solar field, in response to the California Energy Commission (CEC) Staff Data Requests 13-15 for the Blythe Solar Power Project (09-AFC-6C), dated May 29, 2012. Staff requested:

- A map that shows the approximate number and locations of panel foundations that would be placed in the washes that cross the site;
- An analysis showing how much scour might be expected along panel foundations in the washes; and
- The measures that would be taken to mitigate any erosion impacts that would compromise the stability and reliability of the panels.

Enclosed herein is an analysis to respond to these Data Requests (DRs), in particular to DR 14. This analysis examines the extent of scour expected both with and without panels present on-site, and using two different methodologies. The methodologies are:

- 1) Los Angeles County Department of Public Works (LACDPW) Sedimentation Manual (SM) method, and
- 2) FLO-2D numerical modeling method.

The scour calculations are based on maximum flow depths and maximum velocities resulting from the 100-year, 24-hour rainfall event (Figure DR14-1 and Figure DR14-2, respectively) under post-development conditions. Values for maximum flow depth and velocity were obtained from FLO-2D model output files developed as part of the Pre/Post-Development Hydrology Report (AECOM 2013) that was included as Appendix C of the Blythe Solar Power Project (BSPP) Petition to Amend (PTA) filed in April 2013 (“BSPP Hydrologic Evaluation”). A brief description of each method is presented, followed by the results, and then our conclusions regarding the findings.

## Description of the Scour Analysis Methodologies

Modifications to the alluvial fan bed are measured as bed adjustment in feet. Positive adjustment indicates aggradation and negative adjustment indicates degradation (e.g., scour, where degradation is shown as negative values on the figures). To be conservative, only negative adjustment, degradation and scour, are considered here. Several types of adjustment are considered in this study including general adjustment, long-term adjustment, and other scour. General adjustment is scour that occurs in an individual discharge event. Long-term adjustment consists of alluvial processes that occur over several years. Although considered, it was decided that long-term adjustment would not be included in this analysis since the present project does not alter the watershed hydrology, so no long-term bed changes are expected to result from the project's minimal changes to hydrology. In the present analysis, other scour is made up of local pier scour.

### 1. Los Angeles County Department of Public Works Sedimentation Manual Method

The LACDPW SM method follows from Federal Highway Administration (FHWA) HEC-18 criteria for scour at bridges. This method sums the general adjustment, long-term adjustment (not included in this analysis, as stated above), and other scour to arrive at a total scour depth. Both the general and long-term adjustment may be positive or negative, however, to be conservative only the negative (degradational) components are considered here. For the purposes of the present analysis, only pier scour is considered in other scour. General adjustment was calculated using the SM General Degradation Design Curve, presented in Appendix C (page C-3) of the Sedimentation Manual (2006), and for the purposes of the present analysis is given as:

$$GA = 0.0102v^2 + 0.1092v - 0.0275$$

where GA is the general adjustment in feet, and v is the velocity in feet per second (fps). Velocity was calculated using FLO-2D numerical modeling described in the BSPP Hydrologic Evaluation. Pier scour was calculated using the SM equation after Neill (1964), presented in Appendix C of the Sedimentation Manual, and given as:

$$PS = 1.04h^{0.65} v^{0.43} d^{0.135}$$

where PS is pier scour in feet, h is the depth of flow in feet, and d is the pier diameter in feet. For all calculations d is assumed to be equal to 0.5 feet.

## **2. FLO-2D Sediment Transport Numerical Modeling**

The FLO-2D numerical model is designed to be utilized for delineating flood hazards or designing flood mitigation. The model is made up of a series of modules that separate analysis into component parts including rainfall, channel discharge, overland flow, street flow, infiltration, culverts and other physical features. Channel discharge, as well as street flow, is modeled in one-dimension. Overbank flow is computed when channel capacity is exceeded. A full description of the model software can be found in the model documentation, and details of the numerical modeling are located in BSPP Hydrologic Evaluation.

Sediment data used in the FLO-2D sediment transport analysis were taken from sieve analyses of soil samples presented in Kleinfelder (2009). The parameters used in the FLO-2D analysis that were based on the soil data in the Kleinfelder Geotechnical Report (2009) included the transport equation, the gradient coefficient, the  $D_{50}$ , and the grain size distribution. The Yang transport equation was used because this empirical relationship was determined to be representative of the general soil characteristics across the project site.

### **Scour Analysis Results**

#### **1. LACDPW SM Method Results**

The result of the general adjustment analysis is shown in Figure DR14-3. The figure shows that the general adjustment ranges from 0.00 to 0.12 feet of degradation during the 100-year, 24-hour event. The results of the analyses for pier scour and total adjustment are shown in Figure DR14-4 and DR14-5, respectively. The analysis indicates that pier scour is expected to range from 0.03 to 1.47 feet over the project site for the 100-year, 24-hour event. The total scour (general adjustment plus pier scour) is expected to range from 0.03 to approximately 1.57 feet over the project site during the 100-year, 24-hour event when based on the LACDPW SM method.

Based on these results and review of Figures DR14-2 – DR14-5, one can see that the total scour is dominated by pier scour, while general adjustment contributes a relatively small percentage of the total. The maximum total scour will occur where piers will be located (to be determined during final design) and where the flow velocity (shown on Figure DR14-2) is the greatest during the 100-year, 24-hour precipitation event. As shown on Figure DR14-2 (Max Velocity for 100-year storm event), velocities on the BSPP site are relatively low, with a maximum velocity as mostly less than 0.8 fps, and in all cases less than 1.4 fps. The relatively low velocity across the site leads to relatively low total degradation calculated as mostly less than 1 foot (as shown on the figures),

but less than 1.6 feet where velocity and/or depth is the greatest. As these results are for the 100-year, 24-hour precipitation event, they are considered worst-case for design purposes, and more frequent precipitation events are expected to produce less scour over the project site.

As stated above, this analysis assumed a pier diameter of six inches, and it is noted that piers of larger or smaller diameters could result in different depths of design scour that will be accounted for in the final design.

## **2. FLO-2D Method Results**

The FLO-2D model was run to simulate the sediment transport associated with the 100-year, 24-hour precipitation event. The bed adjustment values resulting from the simulation are shown in Figure DR14-6. The FLO-2D model results indicate bed adjustment (degradation only) ranging from 0.00 to 1.20 feet within the project site. The FLO-2D method shows a slightly greater general bed adjustment than the general adjustment for the SM method. Figure DR14-7 shows the bed adjustment resulting from the sum of the FLO-2D and pier scour analyses (using the same pier scour values calculated using Neill's method). The combined FLO-2D bed adjustment and pier scour indicates that the total scour is expected to range from 0.03 to 1.64 feet.

Similar to the LACDPW SM method, the results indicate that the greatest degradation is largely confined to the relatively shallow and narrow feeder channels with somewhat higher relative velocity and concentrated flows. However, total scour remains less than 1.7 feet with this method for the 100-year, 24 hour event, and total degradation is expected to be less during the more frequent, less intensive precipitation events.

## **Comparison of Results of the Two Methodologies**

Two methodologies using different analytical approaches to determining scour were applied, to aid in removing bias from the analysis. A comparison of the minimum and maximum scour estimates for each methodology is presented in Table DR14-1. A comparison of total adjustment estimated by both the LACDPW SM and FLO-2D methodologies shows that both methods predict a similar magnitude of scour during the 100-year, 24-hour precipitation event. A comparison of Figures DR14-5 and DR14-7 (total degradation for the two methods, respectively) indicates that the LACDPW SM method predicts degradation over a larger portion of the overall project site, while the FLO-2D method indicates a lesser areal extent of scour, but with slightly greater maximum scour: 1.57 vs. 1.64 feet, respectively, for the 100-year, 24-hour precipitation event.

Because of the relatively low depth of total degradation calculated over the project site, only simple adjustment to the final engineering design of the PV panel support structures, such as post length or scour protection, may need to occur where panels are located in areas of higher on-site depth and/or velocity. However, it is expected that best management practices (BMPs) for the control of erosion and sediment transport will be employed as the primary mitigation for potential scour, to ensure the stability and reliability of the PV panels.

**Table DR14-1: A comparison of LACDPW Sedimentation Manual and FLO-2D minimum and maximum adjustment estimates**

<b>Methodology</b>	<b>Min Adjustment (ft)</b>	<b>Max Adjustment (ft)</b>
LACDPW SM General Adjustment	0.00	0.12
Other Scour (Pier)	0.03	1.47
Total Adjustment (General + Pier Scour)	0.03	1.57
FLO-2D Bed Adjustment	0.00	1.20
FLO-2D Bed Adjustment + Pier Scour	0.03	1.64

**Conclusions:**

To address the specific question presented in DR14, two different analyses were employed: one numerical and one empirical. The results, shown in Figures DR14-5 and DR14-7, illustrate the expected scour at the panels during the 100-year, 24-hour design event over the entire project site. No aggradation is considered in the analysis to be conservative. It is important to note that the figures illustrate the scour potential assuming that panels could be located everywhere onsite, and do not account for the location of roads and other related infrastructure. Further, the analysis assumes that the support piers/posts for the PV panels employed throughout the field will have a six inch diameter supports, which is a typical installation for this type of structure on project sites with similar geotechnical attributes.

This analysis includes both general adjustment and local pier scour. Both the general adjustment and local pier scour are combined wherever foundation elements for PV panels will be present. Each of the methodologies employed in this analysis produce similar results for total scour during the 100-year, 24-hour precipitation event, with an approximate spatial variation of total scour from 0.03 to 1.64 feet. Nowhere is total scour greater than 2 feet, and more frequent events are expected to produce less total degradation. The calculated total scour is relatively low considering the low frequency of the 100-year, 24-hour event simulated.

Generally, the erosion caused by scour can be mitigated using off-the-shelf BMPs including soil binders. Other mitigation strategies may include local site grading and panel support placement design. A draft Drainage, Erosion, and Sediment Control Plan (DESCP) for BSPP has been prepared (see Attachment DR15). This DESCP document provides the BMPs that are proposed for this Project to minimize erosion and sediment transport, and hence is expected to minimize damage to the PV panels and reduce scour during the more frequent precipitation events.

**REFERENCES:**

AECOM. 2013. Pre/Post-Development Hydrology Report. Blythe Solar Power Project (09-AFC-6C). Provided as Appendix C (BSPP Hydrologic Evaluation) of the Revised Petition for Amendment to the California Energy Commission.

([http://www.energy.ca.gov/sitingcases/blythe\\_solar/pv\\_amendment/rev-amendment/BSPP\\_Revised\\_PTA\\_Appendices.pdf](http://www.energy.ca.gov/sitingcases/blythe_solar/pv_amendment/rev-amendment/BSPP_Revised_PTA_Appendices.pdf))

Federal Highway Administration (FHWA). 2001. Publication Number: NHI-01-001 Evaluating Scour at Bridges, Fourth Edition.

Kleinfelder. 2009. Preliminary Geotechnical Investigation Report. Submitted as part of Application for Certification Volume 3, Data Adequacy Supplement for Blythe Solar Power Project (09-AFC-6).

Los Angeles County Department of Public Works. 2006. Sedimentation Manual (SM), Second Edition. March.

Neill, C.R. 1964. River bed scour – a review for engineers, “Canadian Good Roads Association Technical Publication No. 23.

NextEra Blythe Solar Energy Center, LLC. 2013. Blythe Solar Power Project Revised Petition for Amendment. April.



























